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OUTLINE OF A COURSE IN FISHERIES BIOLOGY AND MANAGEMENT FOR COMMERCIAL FISHERIES TRAINEES

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PREPARATION OF THIS DOCUMENT

This outline was prepared by Mr. David B. Thomson during his service as Training Officer with the FAO/UNDP Marine Fisheries Training Project in Indonesia. It is a first step toward meeting the need to provide commercial trainees at fishery schools with a basic understanding of fisheries biology and management. Users of the outline are encouraged to inform the FAO Fisheries Department of any modifications they find helpful in teaching, so that these changes can be incorporated in a revised version.

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FAO Fisheries Circular (FAO Fish.Circ.)

A vehicle for distribution of short or ephemeral notes, lists, statistical tabulations, etc., including provisional versions of documents to be issued later in other series.

FOREWORD

This course is designed for commercial fisheries trainees who would in time become captains, skippers, fleet managers, or fish plant operators. It is assumed that such students have no background in biological science.

The purpose of the course is to equip fishery industry personnel with an understanding of the nature of fishes and the factors which affect their abundance or depletion. A main objective of the training would be to enable the trainees to make such decisions in the course of the operation of their vessel, fleet or fish plant, as will contribute toward maintaining the optimum sustainable yield from their fishery.

The course includes some general instruction in marine biology and fisheries science. It is felt that the lessons dealing with fish stock evaluation and management would be best handled as part of a general course in biology, rather than in a course of their own. Most technical fisheries schools have at least one course in fisheries biology included in their curriculum. The course is divided into 23 or 24 main lectures plus examinations so it may be administered as follows:

In a Semester-Based Programme	One 2-hour class per week	Plus field trips
In a Term-Based Programme	Two 2-hour classes per week	
As a Single Full-Time Course	Two weeks (including field trips)	

Because many countries have substantial freshwater fisheries, a lecture on freshwater fishes and their cultivation is included. This lesson, number 10A, may be added to the course, or substituted for one of the less important marine fish lectures, or left out, whichever is appropriate.

This outline sets forth the topics to be considered in the course, and summarizes the general discussion of these topics. The interest and effectiveness of the course as given in a particular place, however, will depend largely on the instructor's diligence and ingenuity in drawing illustrations, exercises and examination questions from the local or national fisheries of immediate concern to the students.

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FISHERIES BIOLOGY AND MANAGEMENT FOR COMMERCIAL FISHERIES TRAINEES

COURSE SUMMARY

Lecture No.	
1	Course Preview and Discussion
2	Ocean Structure and Currents
3	The Deep Oceans
4	Continental Shelves and Coral Reefs
5	Coastal Regions
6	Commercial Fishes: The Ocean Dwellers
7	Commercial Fishes: Coastal Pelagic Species
8	Commercial Fishes: Bottom Feeders
9	Commercial Fishes: Shellfish
10	Commercial Fishes: Miscellaneous Species
10A	Commercial Fishes: Freshwater Species (Optional lecture)
11	Basic Marine Ecology
12	Marine Pollution and Fishing Pressure
13	Examination
14	World Fish Catch
15	How Fish Stocks are Measured
16	The Behaviour of Exploited Fish Populations
17	Fishery Yields and Fishing Effort
18	Determining Maximum Sustainable Yield
19	Fishery Management Controls
20	The Selectivity of Fishing Gear
21	Fisheries Legislation
22	Diagnosing Fishery Condition
23	Current Fisheries Conflicts
24	Examination
25	Course Review: Final Discussion

FIELD TRIPS

1	At least one sea trip on a commercial fishing vessel to observe operational procedures, fishing gear and catches obtained
2	At least one visit to a fish market, noting fish species and sizes landed, the local price structure and the fishing fleet
3	A visit to a net loft or gear factory to see nets being assembled and discuss mesh sizes and dimensions with the technical personnel
4	A visit to a fisheries laboratory to see demonstrations of egg counts and studies on fish species samples or tagging programmes.

LESSON 1: COURSE PREVIEW AND DISCUSSION

INTRODUCTION

The purpose of the course is to furnish the students with knowledge and understanding of COMMERCIAL FISHERIES BIOLOGY and THE MANAGEMENT OF FISHERIES RESOURCES.

The instructor should explain as simply and fully as possible what is entailed in each of those subjects. When the students graduate, they should have acquired a knowledge of the fish species that are commercially important to them, and then should be able to make decisions in their field of operations, which will maintain the resource from which the harvest is taken.

TOPICS COVERED

Course content and purpose. Definitions of fisheries biology and fisheries management; why these are important to commercial fisheries personnel. Fish as a national and international resource, like other produce, whether food, fuel or raw materials. Brief account of fisheries development in the twentieth century, and prospects for the future.

MATERIAL USED

A good general film on fisheries would be a useful conclusion to the lecture. Any of the following from the FAO library would be suitable:

LIFE FROM THE SEA	FAO 859
UNDERWATER STORY	FAO 323
FISHING GROUNDS OF THE WORLD	FAO 292
THE UNKNOWN SEA	FAO 648

EXERCISES

The class should spend an hour discussing their views on such questions as the amount of fish in the sea; how much more can be caught; whether men can actually control fish populations; and what are the implications, for them and their people, of changes in the stocks of fish.

It is important that students' personal views and opinions be aired at the outset because there will be a number of misconceptions or mistaken ideas on the subject. The students should be encouraged to make a fresh evaluation of their ideas in the light of the information that will be forthcoming during the course.

REFERENCE BOOKS

Bardach, J.E., 1969 Harvest of the sea. London, George Allen & Unwin, 303 p.

Gulland, J.A., (Comp.) 1971 The fish resources of the ocean. West Byfleet, U.K., Fishing News (Books) Ltd., 255 p. Rev. ed. of FAO Fish.Tech.Pap., (97): 425 p. (1970)

Kesteven, G.L., 1973 Manual of fisheries science. Part 1. An introduction to fisheries science. FAO Fish.Tech.Pap., (118): 43 p.

Holden, M.J. and Raitt, D.F.S. (eds), 1974 Manual of fisheries science. Part 2. Methods of resource investigation and their application. FAO Fish.Tech.Pap., (115) Rev. 1: 214 p.

LESSON 2: OCEAN STRUCTURE AND CURRENTS

INTRODUCTION

To begin our study of the marine environment we will examine the main physical and chemical properties of the sea. Chief among these are the prevailing winds and currents which provide circulation and mixing of the waters. The earth's rotation induces the trade winds which in turn help to produce the major sea currents. The direction and strength of these currents usually vary from summer to winter, or with the monsoon seasons. Sea temperature is also a major item of importance. The temperature varies from the tropics to the poles, and from the surface to the seabed. The sharp change in temperature separating warm surface water from the cooler deeper body of the ocean, we call the thermocline. It appears as a distinct "step" on a temperature/depth graph, and is important to our understanding of the movements of certain fishes. The salt and mineral content of sea water is another important item of study. On average sea water contains about 35 parts per thousand of salt. Salinity is highest at the tropics and decreases toward the poles (37-34). Minute plant and animal forms in the sea depend on sunlight, oxygen, carbon dioxide and nutrient salts. Areas of upwelling or mixing of large bodies of sea water usually result in major fisheries because of the presence of additional nutrients for marine life.

TOPICS COVERED

Major winds and ocean currents. Sea currents in surrounding national waters. Seasonal changes in currents. Sea temperature, surface and sub-surface. Types of thermocline and their effect on sea life. Mineral properties of the ocean. Salinity measurement. Oxygen content, colour and other phenomena.

MATERIAL USED

A large chart of the world's oceans, showing the major sea currents, should be used for reference. Examples of typical thermoclines should be distributed to students along with lecture notes.

EXERCISES

The students should sketch the major sea currents on simple profile maps of the world. Two sheets should be used, to show the seasonal variation. The major upwelling areas may be shaded in colour.

REFERENCE BOOKS

Coker, R.E., This great and wide sea. New York, Harper & Row. (Reprint of 1947 ed. 1962 published by The University of North Carolina Press, Chapel Hill, N.C.)

Deacon, G.E.R. (ed.), Oceans. London, Hamlyn, 295 p. 1962

Neumann, G., Ocean currents. Amsterdam, Elsevier, 352 p. 1968

Weyl, P.K., Oceanography: an introduction to the marine environment. New York, Wiley, 535 p. 1970

LESSON 3: THE DEEP OCEANS

INTRODUCTION

For study purposes we divide the seas into three main depth divisions: the continental shelves, the continental slopes, and the ocean deeps. Very roughly these three regions would come within the depth ranges 0-500 m, 500-3 000 m and 3 000 m to the deepest parts of the ocean which lie over 10 000 m below the surface. More than half the earth's surface - 77 percent of the area of the oceans - is covered by water more than 3 000 m deep. In terms of volume, the deep oceans contain more than 90 percent of all the sea water on our planet. Yet they are relatively unimportant to commercial fisheries. This is partly due to insufficient mixing within the large bodies of water. Nutrients tend to sink to the deeper colder water, leaving the warmer surface regions rather barren. Where there is an area of upwelling, or where there is a sharp thermocline, fish may be plentiful. Over most of the deep oceans, fish life occurs chiefly in the upper 500 m, and includes tunas, sharks and flying fish. Also present are squids, porpoises and whales.

TOPICS COVERED

Tropical and sub-tropical oceans; their extent, depth and movement. The prevailing winds and currents. Seasonal surface and sub-surface temperatures. Areas of upwelling; their cause and significance. Life in the deep oceans: phytoplankton, zooplankton and deep dwelling species. Surface or near surface species.

MATERIAL USED

If available, a 3-dimensional model of an ocean bed would be useful, otherwise charts and diagrams will suffice. The instructor should try to get the scale of ocean measurements into focus by comparing or contrasting them with other common yardsticks. The National Geographic atlases and maps are extremely good reference items.

EXERCISES

From one or more textbooks or research reports, students should construct a depth contour map or sectional drawing of the ocean bed. Temperature, pressure, light penetration or other data might be added.

REFERENCE BOOKS

Herring, P.J. and M.R. Clarke (eds.), Deep oceans. London, Arthur Barker, 320 p. 1971

LESSON 4: CONTINENTAL SHELVES AND CORAL REEFS

INTRODUCTION

CONTINENTAL SHELVES: Although only 8 percent of the area of the world's seas, and less than 15 percent in volume, lie above a continental shelf, this region is extremely important in fish production. The bulk of the world's fish catch is taken in waters less than 500 m deep.

The point at which the continental shelf meets the continental slope is called the continental edge and it may be arbitrarily considered to lie anywhere between the 200 and 1 000 m depth contours.

Generally speaking the shallower seas experience much more mixing than the deep oceans. The confluence of different currents and rivers results in an abundance of nutrients. Light penetration (albeit limited) to the seabed encourages the development of benthic species and bottom feeders. The whole cycle of life in the shallow seas is very complex and the existence of an individual species is closely inter-related with that of many others. By far the largest group of commercially important species occur in this region.

CORAL REEFS: Composed of myriads of marine animals with stony skeletons, coral reefs are among the most beautiful and the most ecologically important habitats for marine life. The life systems that thrive around coral reefs are as complex as they are productive. Usually reefs are formed at depths less than 40 m, but some reefs extend many hundreds of metres down, due, scientists believe, to subsidence in the seabed. There are three types of reefs: barrier reefs, fringing reefs and atolls.

TOPICS COVERED

CONTINENTAL SHELVES: Extent and nature of the continental shelf as shown on a world map and a regional one. Depth ranges, type of bottom, prevailing currents and mixing influence from other bodies of water, rivers or cross-currents. Groups of species occurring in local shallow seas.

CORAL REEFS: Location of major coral reefs on a world map and local regions where they occur. Types of fish and shellfish found around the reefs. Life cycles in a coral reef environment.

MATERIAL USED

There are many good general films of life in coral reefs and these may be obtained from local or embassy libraries or from FAO. Most marine schools have examples of coral types on display, and they may be examined to see their construction.

EXERCISES

Regional profile maps may be used for students to trace the continental shelf and indicate coral reefs. Where the shelf is sloping, students may calculate the gradient and see how it compares to hills or slopes on land.

REFERENCE BOOKS

Carson, R.L., The sea around us. New York, Oxford University Press, 230 p.
1951

Hardy, A.C., The open sea: its natural history. London, Collins, 2 vols.
1956

LESSON 5: COASTAL REGIONS

INTRODUCTION

The parts of the sea lying close to land often comprise a special habitat for fish. This merits separate attention in our course. We will look at straits, estuaries and mangrove swamps.

STRAITS: Where two seas meet at a narrow stretch of water between islands or between an island and the mainland, there is a considerable mixing effect in the waters. This is often visible on the surface where two tidal streams or currents meet. At these straits, groups of fishes may be found in abundance as they feed on the nutrients brought to the surface in the area of turbulence.

ESTUARIES: Where rivers discharge into shallow bays or enclosed seas, there may be extensive estuarine regions of brackish water, low in salinity but high in nutrients, which support particular fish populations. Some species like shrimp are spawned and/or reared in estuarine areas although they may spend much of their adult life in deeper parts of the sea. Because they lie so close to shore, in shallow waters, estuarine areas are particularly vulnerable to urban or industrial pollution.

MANGROVE SWAMPS: Some low-lying coastal regions in the tropics support large mangrove swamps. These are forests of mangrove (Rhizophora) trees which thrive in the mud flats along the sea shore. Like the coral reefs, the mangrove swamps support large populations of marine creatures like crabs, barnacles and fishes which find shelter around the roots of the trees.

Note: If mangrove swamps do not occur in the country then the instructor might prefer to deal with lagoons or sheltered bays as appropriate.

TOPICS COVERED

Local straits, tide strengths and effects, temperature and/or salinity difference of waters, mixing effect, species found in the immediate vicinity.

Local estuaries, volume of water discharged from the rivers, its nutrient content. Tidal effects. Species living all or part of their lives near estuaries. Seafish that spawn in freshwater.

Mangrove swamps, their local occurrence if any, fishes found in their vicinity. Local lagoons, or sheltered bays, their size, depth, and fish populations.

MATERIAL USED

A film like "Time of Migration" (FAO 318 A) or "The Salmon's Struggle for Survival" (CANADA 106c0157050) may be useful. Outline maps may also be used to illustrate the extent of estuarine or brackish water, and the location of "tide rips" near straits.

EXERCISES

Have the students compare the totally different nature of estuaries and straits although they both occur close to the land. Have them also trace where the fish come from to these places, and why. What, if anything, does this tell them about the seasonal nature of the local fishery and its relation to offshore fisheries?

REFERENCE BOOKS

McLusky, D.S., Ecology of estuaries. London, Heinemann, 144 p.
1971

Perkins, E.J., The biology of estuaries and coastal waters. London, Academic Press, 678 p.
1973

LESSON 6: COMMERCIAL FISHES: THE OCEAN DWELLERS

INTRODUCTION

Now that we know something about the marine environment, we will begin to study the fish species that live there. For our purposes we will divide them into 5 groups: ocean dwellers, coastal pelagic species, bottom feeders, shellfish and miscellaneous types.

OCEAN DWELLERS: The largest of the groups of "ocean dwellers" that are commercially important to us, is the tuna family. Species from this group are found in each major ocean from the equator to the sub-temperate zone. Other important ocean dwellers are sharks, swordfish and whales (now endangered species). We shall discuss other ocean dwellers like squid and flying fish in Lecture 10.

TOPICS COVERED

Elementary study of the life cycle, migratory, feeding and breeding habit of the following species:

ALBACORE:	Thunnus alalunga
BLUEFIN TUNA:	Thunnus thynnus
YELLOWFIN TUNA:	Thunnus albacares
SKIPJACK:	Katsuwonus pelamis

THE SHARKS: Brief study of the important shark species, detailing their different reproductive systems and behaviour.

PORBEAGLE & MAKO SHARKS:	Lamnidae, Isuridae
DOGFISH & BLUE SHARKS:	Squalidae, Carcharinidae
HAMMERHEAD SHARKS:	Sphyrnidae

SWORDFISH & MARLIN: Brief mention of other ocean swimming species such as Xiphias gladius and Makaira spp.

Note: If the instructor deems appropriate he may wish to mention the stocks of whales, the huge ocean swimming mammals, once so abundant, and now reduced to the point where their existence is threatened.

MATERIAL USED

Colour charts, pictures or slides of tuna, shark and other ocean swimming fish, would be most useful. The instructor may provide sketches showing the development of tuna from eggs, and of sharks from birth. Students should grasp clearly the distinctive physical and behavioural attributes of the main species.

EXERCISES

Students should make a scale colour drawing of at least one tuna and one type of shark. The profile drawings in the FAO Species Identification Sheets are useful for reference as to size and proportion. Colour pictures are available in most fish books and charts. The FAO film "Tuna Fishing" (No. 322) may be shown.

REFERENCE BOOKS

Matthews, L.H., The whale. London, Allen & Unwin, 287 p.
1968

Nakamura, H., Tuna distribution and migration. London, Fishing News (Books) Ltd., 76 p.
1969

LESSON 7: COMMERCIAL FISHES: COASTAL PELAGIC SPECIES

INTRODUCTION

This is probably the most important group of fishes in the world catch. Occurring in dense schools near the coast in productive areas, and capable of reproduction at a high rate, they were once thought to be an inexhaustible resource. Today, with modern methods of location and capture, this group of fishes is as vulnerable as any other. Most of these fish contain a good deal of oil as well as protein. Their use for the production of animal feed (fishmeal) is a rather round-about way of feeding humanity.

TOPICS COVERED

The life cycles of the following species, their food, behaviour and migratory habits. Spawning times and locations; free-floating spawn and rock-adhering spawn. Age and size of fish at maturity. Reaction to light and temperature, especially diurnal and nocturnal movements. (Particular attention should be paid to those species occurring in the country or region.)

HERRINGS, SARDINES, MENHADEN:	Clupeidae
ANCHOVIES:	Engraulidae
MACKERELS:	Scombridae
JACKS:	Carangidae

MATERIAL USED

Colour charts, pictures or slides of the species listed are invaluable. The instructor should make sure that the students are aware of the relative size of each species at maturity. Data on spawning and migratory behaviour may be available only from biological reports.

The instructor should obtain as much of this material as possible from local research institutes, and should prepare suitable teaching aids or handouts himself. Example of good charts and diagrams can be found in some of the books on the herring, and in Hela & Laevastu's Fisheries Oceanography.

EXERCISES

Each student should write a brief account of the life cycle of one of the species mentioned, detailing its growth, movements and behaviour from spawning to full maturity. They should have access to reference books for this purpose.

REFERENCE BOOKS

Culley, M., The pilchard: biology and exploitation. Oxford, Pergamon, 241 p. 1971

Hodgson, W., The herring and its fishery. London, Routledge & Kegan Paul, 197 p. 1957

LESSON 8: COMMERCIAL FISHES: BOTTOM FEEDERS

INTRODUCTION

The demersal or bottom feeding fishes comprise the bulk of the species caught in bottom trawls, bottom set gillnets, fish pots and longlines. They are a rather mixed group including flatfish, rays, gadoids, bream and odd types like the angler fish and john dories found all over the world. These bottom dwellers are found on the continental shelves along our coasts, from the tidal zone to 500 m depth. Note that the "bottom feeder" does not imply that they never swim in midwater or close to the surface.

TOPICS COVERED

For at least four selected species appropriate to the country or fishery concerned, details of their life cycle, food and spawning behaviour. Brief summary of other important bottom fish in the regional fishery. Some examples are listed below.

SNAPPERS:	Lutjanidae
BREAMS:	Sparidae
ROCKFISH:	Scorpaenidae
MULLETS:	Mullidae, Mugilidae
COD, HAKE, POLLOCK:	Gadidae
GROUPERS:	Serranidae
DRUMS:	Sciaenidae
FLATFISH:	Soleidae, Bothidae, Pleuronectidae
GRUNTS:	Pomadasidae
SKATES & RAYS:	Rajidae
ANGLER FISH:	Lophidae

MATERIAL USED

A colour chart is essential to display a reasonable variety of local demersal fish. The instructor should draw attention to the commoner examples from the groups of bream, gadoids, flatfish and rays. Some attention should be paid to preferred bottom types and for this, a sample of mud, sand, shell and/or stony bottom would be useful.

EXERCISES

Students should draw up a list of local bottom fishes giving their common or local names as well as their scientific names. In separate columns they should also list, as far as can be obtained, their preferred types of food and habitat or seabed. Where known, their spawning season should be noted. In obtaining such data, the students should be encouraged to consult commercial fishermen as well as scientific or research reports.

REFERENCE BOOKS

Alverson, D.L., A.T. Pruter and L.L. Ronholt, A study of the demersal fish and fisheries
1964 of the northeastern Pacific Ocean. Vancouver, B.C., Institute of Fisheries, University of British Columbia, 190 p.

Munro, J.L. (ed.), The biology, ecology, exploitation and management of Caribbean reef
1974 fishes. Kingston, Jamaica, University of the West Indies, 5 vols.

LESSON 9: COMMERCIAL FISHES: SHELLFISH

INTRODUCTION

Shellfish are among the most valuable species in the sea by weight. Most of them dwell on (or in) the seabed and some species thrive in the tidal zone or in estuarine waters. Most shellfish are vulnerable to over-fishing and to pollution of their seawater environment. Because of their vulnerability to over-fishing, most countries seek to protect their stocks of crustaceans by legislating against the capture of immature or egg-bearing shellfish, particularly lobster, crab and crawfish. Shrimp are the most prolific of the crustaceans and shrimp fisheries need to be controlled to ensure adequate recruitment to the stock.

Important molluscs include scallops, oysters, clams and mussels.

TOPICS COVERED

SHRIMPS: Life cycle and habits of the main penaeid species, with special attention to those species occurring in local waters; their habitat and distribution.

CRABS, CRAWFISH, LOBSTER: Brief study of local species in these categories, describing their habitat, life cycles, food and predators.

SCALLOPS, CLAMS, OYSTERS: Important commercial molluscs of the region; their particular life cycles and habitats. The dangers of inshore and estuarine molluscs absorbing toxic materials from polluted waters should be explained. Artificial rearing methods might be mentioned.

MATERIAL USED

There is a fair amount of teaching material available on the biology and life cycles of shellfish. The instructor may prepare a flip chart illustrating the development and migration of species from spawning to maturity. Should any small shellfish aquarium or holding tanks be located in the vicinity, a visit to one would be in order.

EXERCISES

Following an explanation of the preferred habitat of local shellfish, students may trace on marine charts, the regions where certain molluscs and crustaceans may be found, as the bottom topography, seabed type, depth and salinity relate to the creature's preferences.

REFERENCE BOOKS

Green, J., A biology of crustacea. Chicago, Quadrangle, 180 p.
1963

Prudden, T.M., About lobsters. Freeport, Maine, Bond Wheelwright, 158 p.
1962

LESSON 10: COMMERCIAL FISHES: MISCELLANEOUS SPECIES

INTRODUCTION

Among the many commercially important species not previously mentioned in the course are salmon, eels, squid, cuttlefish, flying fish, sturgeon, turtles and other marine organisms not necessarily of food value, such as sea-shells, sponges and seaweeds. Salmon

occur in the north Pacific and north Atlantic. They belong to that interesting group of fishes that spawn in freshwater but spend most of their juvenile and adult life in the ocean. Eels live a somewhat reverse existence, spawned and hatched in the ocean, and migrating up rivers until ready to spawn again. Squid are marketable cephalopods which probably constitute one of the largest single stocks of under-exploited species in the sea. They occur in almost every marine region from the equator to the polar seas, and at depths ranging from the surface to many hundreds of metres. Flying fish are widespread and fairly abundant in tropical seas. These very edible fish are not exploited much outside of Japan. Marine mammals, reptiles, sponges and weeds are utilized in many places but their exploitation needs to be controlled to prevent over-fishing.

TOPICS COVERED

The life cycles, food, habits and distribution of:

SALMON:	Oncorhynchus spp., Salmo salar
EELS:	Anguillidae
SQUID:	Loliginidae
CUTTLEFISH:	Sepiidae
OCTOPUS:	Octopus spp., Polypus spp.
FLYING FISH:	Exocoetidae

plus other marine creatures as appropriate.

MATERIAL USED

Apart from slides and charts of species and their life cycles, a film such as "The Salmon's Struggle for Survival" (CANADA, 106c0157050) would be appropriate, or "Red Runs The Fraser" (FAO 313), or "Aalvissery" (eel fishing) (FAO 848).

EXERCISES

Students may sketch any of the species available locally, and indicate their distribution.

REFERENCE BOOKS

Cousteau, J., Octopus and squid. New York, Doubleday, 304 p. 1973

Mills, D., Salmon and trout. Edinburgh, Oliver & Boyd, 351 p. 1971

LESSON 10A:[1] COMMERCIAL FISHES: FRESHWATER SPECIES

INTRODUCTION

More than nine million tons of fish are produced annually by the world's lakes and rivers. Most of these fish come from tropical and sub-tropical regions. Apart from salmon and similar sea-migrating species, there is not much fish produced in cold-region lakes and rivers. The possibilities of farming freshwater species has led to the development of innumerable small ponds and dams which farmers use both for storing irrigation water and for

1/ This lesson may be substituted for any one of lessons 6 to 10 for countries which have substantial freshwater fisheries.

producing fish to supplement the crop and animal production. Carp and tilapia are the two most important kinds and they are fished and farmed throughout Asia and Africa. Catfish are also important, and in some regions there are considerable stocks of perch and freshwater sardine. The life cycles of these species are as varied as they are interesting and we can but mention a few salient points in this lesson. Given adequate food, oxygen, and suitable temperature, the growth and reproduction rate of freshwater fish can be remarkably high. In some situations, the stocking of ponds, lakes or rivers with young fish can be a successful method of production intermediate between harvesting wild stocks and raising fish in artificial impoundments. Whether stocked or wild, fish confined to small habitats such as small lakes and rivers also need some protection against overexploitation.

TOPICS COVERED

Distribution, physiology, habits and life cycles of some of the following species as appropriate to the region:

TILAPIA:	Tilapia spp., Seratherodon spp.
CARP:	Carassius spp., Cyprinus spp.
CATFISH:	Clarias spp., Ictalurus spp.
TROUT:	Salmo spp.

MATERIAL USED

Map of the inland waters and rivers of the region, and a wall chart or slides of appropriate species.

The FAO film "Wealth in Pond" is ideal for illustrating tilapia culture. "Fish Farming in the Himalayas" (No. 854) is also helpful.

EXERCISES

Students should make a colour drawing of at least one species and should indicate its distribution, food and spawning habits.

REFERENCE BOOKS

Bardach, J.E., J.H. Ryther and W.O. McLarney, Aquaculture. New York, Wiley, 868 p. 1972

Macan, T.T., Freshwater ecology. London, Longman, 2nd ed: 343 p. 1974

LESSON 11: BASIC MARINE ECOLOGY

INTRODUCTION

Each fish population has a natural preference for a particular marine environment. The factors which comprise the environment are complex and inter-related. Each species' preferences are subject to differing variables depending on growth stage, season and time of day. These variables are so complex that it is not possible to be precise in our predictions of the location of fishes at any one time. We can however, make some generalizations which will help us to identify the behaviour of different fish populations under a given set of conditions. The chief elements in the marine environment which we study in fisheries ecology are:

temperature
oxygen content
nutrient content
salinity
pressure (depth)
light penetration
bottom type and topography
currents and tides
food availability
predators and natural enemies

Note that ecological elements like temperature, salinity, oxygen and light affect not only mature fish but can be critical to the hatching and survival of larvae. Thus it is vital that spawning takes place in the correct environment. The control of the salt balance in fishes is a complex process involving osmosis and gill and kidney actions. Diadromous fish like eels and salmon can move from fresh to salt water at certain times but other fish do not have this ability to adjust to large changes in salinity. Temperature changes below or above a fish's normal range can reduce its activity or affect its breathing and metabolism.

TOPICS COVERED

Explanation of the meaning of each element listed above with examples of their effect on different species. The best local or regional examples of this should be used for illustration. The movements of tuna, shrimp and sardine relative to different factors may be described. The annual or seasonal factors should be separated from those which are of day-night importance only.

MATERIAL USED

Some of the sketches and diagrams in the Open Sea or Fisheries Oceanography could be adapted for use on a static visual or slide. Some oxygen, salinity and temperature charts of the oceans would be helpful. They can be obtained from any good marine atlas.

EXERCISES

Students should copy at least one good diagram illustrating marine ecosystems as they relate to fishes.

REFERENCE BOOKS

Hela, I. and T. Laevastu, Fisheries oceanography. London, Fishing News (Books) Ltd., 238 p. 1970

Lagler, K.F., J.E. Bardach and R.M. Miller, Ichthyology. New York, Wiley, 545 p. 1962

Nikolsky, G.V., The ecology of fishes. London, Academic Press, 352 p. [Translated from 1963 the Russian by L. Birkett]

Tait, R.V., Elements of marine ecology. London, Butterworths, 272 p. 1968

LESSON 12: POLLUTION AND FISHING PRESSURE

INTRODUCTION

Apart from the natural hazards which all marine life faces in the struggle for survival, there are a growing number of man-made factors which further reduce the survival rate. The greatest of these is fishing pressure which is not a threat to the existence of species providing it is kept within reasonable limits. More insidious in the long term are man's activities as a polluter or destroyer of the marine environment. It was formerly believed that the oceans were so vast that urban and industrial pollution could never make any significant change to its life-supporting systems. Today we realize that it is all too possible to poison the seas with our toxic wastes. Hundreds of rivers that once swarmed with fish are now almost sterile. Some seas are dangerously close to this condition (the Baltic is an example). Pollution of rivers may be caused by pulp mills or by the untreated wastes from chemical factories. Normal human wastes are not as serious a source of pollution as might be thought. Sea pollution may be caused by large oil spills or by the combined effluence from large industrial cities. Nuclear wastes of radioactive material may be a major source of pollution in years to come if they are not otherwise disposed of. Man's activities in destroying the marine environment can also be detrimental to fish stocks. This could include the damming of rivers or the destruction of coral reefs. Sometimes the construction of submarine installations like oil-rigs can have a beneficial "sheltering" effect on fish, providing that this marginal benefit is not nullified by oil pollution. Dredging and filling in coastal waters can destroy important shallow-water habitats, including nursery areas. To sum up the last two lessons, it can be said that fish stocks are limited by environmental and ecological factors; that the environment, and hence fish stocks, may be affected by pollution; and that fishing will also influence the size of stocks. (The instructor will only introduce the subject of fishing pressure in this lecture; it will be discussed fully later. But at this point the students should learn to distinguish the three factors listed.)

TOPICS COVERED

Tolerances of fish to various kinds of pollution. Sources and types of pollution. Local examples. Toxic wastes, effect on fishes and on humans eating contaminated fish. Necessity of maintaining oxygen content of water.

MATERIAL USED

The film "Fish Und Wasser", FAO 853, may be used. The instructor could provide commentary if the students do not understand German.

EXERCISES

In view of the examination due next, students should review all prior work.

REFERENCE BOOKS

Ruivo, M. (ed.), Marine pollution and sea life. West Byfleet, U.K., Fishing News 1972 (Books) Ltd., 624 p.

LESSON 13: EXAMINATION

Students should be examined on the content of Lectures 1 to 12 to ascertain their progress to date, and to ensure that they have gone over all the work during their evening studies. The examination should consist of two parts: first, the submission of a brief

term paper which they should have completed in their own time during the previous week, and second, a test paper containing about ten questions which should be completed within the examination time of 60 to 90 minutes.

TERM PAPER

Students should be asked to submit a paper of about 1 000 or 2 000 words on a topic of their choice within the general subject of Marine Fishes and Their Environment. They should be encouraged to illustrate the paper with charts, drawings, diagrams or tables, and should aim at quality rather than quantity.

During the preparation they should have access to the school library, though all material drawn from books should be acknowledged.

EXAMINATION

The ten questions designed to evaluate the students' knowledge and understanding of the subject matter should cover the following items:

Seas, Oceans and Inshore Waters - Their Characteristics
Life Cycles and Food Chains in the Sea
Effects of Seasons, Monsoon, Ocean Currents
Seabed Types and the Life Systems They Support
Habitat of Main Commercial Species
Migratory Behaviour of Some Fishes
Development of Mature Fish from Fertilization through Larvae and Juvenile Stages
Food of Fishes
Hazards to Fishes - Natural and Man-made

LESSON 14: COMMERCIAL FISHERIES OF THE WORLD

(Note: Following the results of the examination, the instructor may need to revise some of the points covered in previous lectures, or to correct misunderstandings. Assuming, however, that reasonable progress has been made, the second and more vital part of the course should now get under way.)

INTRODUCTION

The estimated total world fish catch has risen enormously in this century. In the past 40 years alone it has more than trebled from 21 million metric tons to 65-70 million metric tons. Recent years have seen a levelling off in the catch after the remarkable increase in the 1950-70 period. There have been many optimistic predictions of world catch increases up to 100 or even 200 million metric tons, but most of these presuppose a more general harvest of marine species rather than a larger harvest of the commercial fishes we know today. Some species have been fished beyond the point where they could replenish their stocks and drastic measures have had to be taken to permit the population to recover its size, and to prevent a recurrence of the same thing. Among these groups are whales, Peruvian anchovy, Atlantic herring, Atlantic menhaden and other more localized fish populations.

TOPICS COVERED

Summary of world and regional catch statistics, by countries and by groups of species. National fishery statistics; recent trends; lessons to be learned (if appropriate) from neighbouring fisheries. Long term goals in fishery planning. Need for wise management of fishery stocks both from biological and economical viewpoints. Future prospects for the national fishery.

MATERIAL USED

Some general graphs illustrating the dramatic rise in the world catch since 1945, and the recent levelling of the annual total landings, may be used to good effect. Any general film on commercial fishing would be applicable, including:

PURSE SEINING IN NORWAY	FAO 312
OTTER TRAWLING	FAO 307
THE SILVER HAUL	FAO 317

EXERCISES

A general discussion on the present level of catches and future prospects for the national fishery may be appropriate for this lecture.

REFERENCE BOOKS

Brandt, A. von, Fish catching methods of the world. London, Fishing News (Books) Ltd., 1972 290 p.

Gulland, J.A., (Comp.) The fish resources of the ocean. West Byfleet, U.K., Fishing News 1971 (Books) Ltd., 255 p. Rev. ed. of FAO Fish.Tech.Pap., (97): 425 p. (1970)

Walford, L., Living resources of the sea. New York, Ronald Press, 321 p. 1958

LESSON 15: HOW FISH STOCKS ARE MEASURED

INTRODUCTION

Marine scientists today are faced with a problem that none of their predecessors had to tackle. Previously biologists studied fish habits and behaviour, but they did not have to quantify fish stocks. Neither did they have the means to accomplish this. Today, the tremendous growth in commercial fishing, which in some cases has exceeded the ability of fish stocks to reproduce, makes it imperative that we know with much greater precision just how much fish there is in the sea. Modern marine biologists are attempting to do precisely this, and they have developed different tools and techniques to achieve accurate results.

FISHERY STATISTICS are one means of gauging the size of stocks. They are by no means a real indicator and must be used with considerable caution. Statistics of any kind are liable to misinterpretation! To be useful, catch statistics must be reliable and there is no substitute for accurate recording of fish landings, fishing effort and catch composition.

FISH SPAWNING AND GROWTH STUDIES comprise a biological approach to the problem. Egg counts are made on the roes of mature fish, and on the results of tows with plankton nets at specified stations in the sea. The growth rate of fish is measured through tagging programmes, scale counts and aquarium studies. From estimates of egg production, mortality rates, growth rates and age at maturity, the biologists can sometimes provide valuable information on the expected stock size one, two, or even three years in advance.

ACOUSTIC SURVEYS are useful in measuring the whole biomass of fish in an area. (They do not discriminate between fish species.) By using special high frequency echo sounders or sonars, coupled to integrators or mini-computers, marine scientists can estimate the abundance of fish in a given region from surveys in selected parts.

TOPICS COVERED

Fishery statistics as a guide to fish stocks. The kind of statistics required, their detail and reliability. Biological studies of fish stocks, egg counts, sampling and tagging programmes. Acoustical surveys. Terms and concepts involved - numbers of spawners, mortality or survival rate, age of recruitment, life expectancy, stock size and fishable stock.

MATERIAL USED

A visit to a marine laboratory or research station should be timed to take place as close to this lesson as possible. The instructor should illustrate the methods with studies of exploited and unexploited stocks in progress in the students' country.

EXERCISES

Students should list the potential reproduction rate of some common species, from spawn production, and contrast this with the annual stock recruitment to discover the survival rate from egg to maturity.

REFERENCE BOOKS (Lessons 15-18 and Lesson 22)

ACMRR (FAO) Working Party on Fishing Effort and Monitoring of Fish Stock Abundance. Rome, 1976 Italy, 16-20 December, 1975. Monitoring of fish stock abundance: the use of catch and effort data. FAO Fish.Tech.Pap., (155): 101 p.

Brander, K., Guidelines for the collection and compilation of fishery statistics. FAO Fish. 1975 Tech.Pap., (148): 46 p.

Gulland, J.A., Manual of methods for fish stock assessment. Part 1. Fish population 1969 analysis. FAO Man.Fish.Sci., (4): 154 p.

Gulland, J.A., Manual of methods for fisheries resource survey and appraisal. Part 5. 1975 Objectives and basic methods. FAO Fish.Tech.Pap., (145): 29 p.

Graham, M. (ed.), Sea fisheries. London, Edward Arnold, 487 p. 1956

Ricker, W.E. (ed.), Methods for assessment of fish production in fresh waters. IBP 1968 Handb., (3): 313 p.

LESSON 16: THE BEHAVIOUR OF EXPLOITED FISH POPULATIONS

INTRODUCTION

We have studied a little about the fish populations which inhabit the seas and have investigated some of the factors which relate directly to their abundance. Now we wish to consider the consequences of exploitation. What really happens to a population that is being harvested? How can we measure the effect? How do factors like the method and time of capture relate to the growth, maturity, and life expectancy of the fish? At what rate can a population reproduce to maintain its numbers in the face of substantial exploitation?

One of the first marine scientists to produce a clear exposition of this problem was E.S. Russell to whom we are indebted for the simplest equation on the dynamics of exploited fish populations. In its simplest form Russell's equation can be written thus:

$$S_2 = S_1 + (A + G) - (M + C)$$

where S_1 and S_2 represents the SIZE (weight) of the stock under study at the beginning and at the end of the period (usually one year), respectively, and
A represents the ADDITIONAL RECRUITS the stock has gained through reproduction,
G represents the GROWTH of the fishes over the period, which will increase the size or mass of the stock,
M represents the loss to the stock through natural MORTALITY, and
C represents the total CATCH over the period.

TOPICS COVERED

Russell's equation. Definition of terms used. Relation of factors to one another. Condition prevailing in a virgin fishery, in a moderately exploited fishery and in a heavily exploited fishery. Fluctuations in year classes. Graphic models and illustrations.

MATERIAL USED

Several clear graphs should be prepared in advance for use as visual aids. The instructor should begin with simple forms of these and introduce variations after he is satisfied that the class has grasped the basic concepts.

EXERCISES

From a given set of hypothetical values for Russell's equation the students may write a theoretical account of the development of a fishery. Conversely they may prepare a set of hypothetical values to account for a given theoretical situation.

REFERENCE BOOKS (see Lesson 15)

LESSON 17: FISHERY YIELDS AND FISHING EFFORT

INTRODUCTION

If there were no fishing activity on man's part, then the size or weight of any fish stock would increase annually according to the numbers reproduced and the growth of each fish, less the amount of fish lost by natural mortality. As per Russell's equation, this would be A + G - M. This is called the NATURAL YIELD. If the amount harvested equals the natural yield, or (C + M) = (A + G), then the fishery is said to be in EQUILIBRIUM. One odd aspect of fishery dynamics is that both under-fishing and over-fishing result in low natural yields, though for obviously different reasons. In fisheries management we try to achieve a level of fishing pressure which will result in the largest continuous yield or maximum sustainable yield from the fishery, so that what we catch this year will not reduce the yield next year or five year's hence or ten year's hence.

The fishing effort needed to obtain this yield is called the BIOLOGICAL OPTIMUM FISHING RATE. As in other sciences we study the elements of a problem separately before we piece together the whole picture. So, with various biological data we can estimate this rate. However, in the world of commerce, economic factors determine the feasibility of any enterprise, and from that point of view we may arrive at a different effort called the ECONOMIC OPTIMUM FISHING RATE.

TOPICS COVERED

Definition and explanation of concepts relating to fisheries in equilibrium. Optimum fishing rates. Biological and economic factors. Graphic models and illustrations.

MATERIAL USED

The instructor may begin with examples from agriculture. In an orchard of fixed area, the production of fruit will be low if there are too few trees or if there are too many trees. Some intermediate number of trees will produce the maximum crop. Similarly, there is some optimum size of a herd of dairy cows that will maximize the production of milk from a given area of pasture. In a fishery, the biological optimum fishing rate is the one that maintains the stock at its most productive size, given the limits of its habitat, and harvests its annual production at that size.

REFERENCE BOOKS (See Lesson 15)

LESSON 18: DETERMINING MAXIMUM SUSTAINABLE YIELD

INTRODUCTION

From our studies of fish populations we can deduce that there is a healthy level or size of population at which it will reproduce and grow at a maximum rate and thus produce the high yield we are looking for. The chief model used as a basis for study by fishery scientists is that developed by M.B. Schaefer. In its simple form, the maximum yield (Ymax) is taken when the population or BIOMASS (Bmax) is equal to half the original or virgin biomass (B_0). The model is of course much more complex than this because of the many variables involved. One of the most important variables is the size of the fish at first capture (at what size or weight relative to full growth we begin to catch the species).

Further analytic models of fish populations have been developed to take into account the rates of recruitment, growth and mortality which will vary with the species, climate and region. Fishing effort needs to be carefully evaluated in such studies, and there are various ways in which it may be gauged. In this course we have time to examine only a few elementary examples of how sustainable yields are calculated.

TOPICS COVERED

Understanding terms relating to yield or catch - catch per population or biomass; catch per recruit; catch per fishing effort. How these figures are calculated. Study of simple graphs relating to sustainable yield per size or age of recruits, and per intensity of fishing effort. Effect of variables in nature and in the fishing industry, on such models.

Economic factors. The cost of fishing effort. Value of catch. Catch per unit effort. Maximum gross return, net economic return and marginal return per cost of fishing effort. (The instructor should resist the temptation to delve into the complexities of this subject, much of which is beyond the scope or abilities of vocational fishery students. Instead he should seek to install in their minds, a clear picture of the elements involved.)

MATERIAL USED

The graphs and diagrams used in the previous two lectures may be supplemented with ones displaying the concepts introduced here. The purpose of these is not to enable the students to carry out stock and yield assessments, but only to help them understand the techniques and procedures used by fisheries scientists.

EXERCISES

Given real or hypothetical data about one particular fishery, students should calculate catch rates per population, per recruit and per effort, for at least three separate years. A discussion on the results may follow if there is time.

REFERENCE BOOKS (see Lesson 15)

LESSON 19: FISHERY MANAGEMENT CONTROLS

INTRODUCTION

If we are to regulate the prosecution of fisheries to achieve sustainable yields then we must have controls of some sort. The ultimate controls are the reduction of the stocks and/or the economic returns from fishing, but we do not want the situation to deteriorate so far before action is taken. Fish stocks can be protected in two ways:

1. by restricting the AMOUNT of FISHING, through licensing units, introducing closed seasons, closed areas, catch quotas, or limiting gear type which may be used.

2. by protecting YOUNG FISH so that more of them can survive to maturity; through minimum landing sizes, minimum mesh sizes or closure of nursery grounds if applicable.

Some of these controls are difficult to enforce and some of them may be unpopular with fishermen for social or economic reasons. If we are to introduce controls at all, they must be ones which will work and which will have widespread support; otherwise enforcement will be impossible or too costly.

Economically, it would be better to have a few profitable fishing units than a large number of unprofitable ones. If unemployment is a problem, then the units should be labour-intensive, but they still ought to be subject to some limitation once the optimum yield is achieved.

Diversification ought to be encouraged to increase the number of species harvested without upsetting the balance of life in the sea. By the same token, fishing effort ought to be spread evenly over all the national waters, rather than concentrated around a few population centres. This may call for changes in the structure of the catching and marketing systems.

TOPICS COVERED

Methods used to control fisheries: closed seasons, quota systems, limited entry, closed areas, mesh size limits, fish size limits, vessel size limits, gear restrictions, etc. Brief examples of each, the ideas behind them, and their side effects, biological, technical, social and economic.

MATERIAL USED

As the use of legislation is studied in Lesson 21, this lecture focuses more on the means of control. They can be illustrated with fishing gear (complete or in part), by the use of models, and by the use of charts with overlays displaying fisheries limits or closed areas.

EXERCISES

In addition to general information on fishery controls students should note and study the means currently used in their country or region.

REFERENCE BOOKS

Gulland, J.A., Guidelines for fisheries management. Rome, FAO, IOFC/74/36, 84 p. 1974

Gulland, J.A., The management of marine fisheries. Bristol, Scientechnica, 198 p. 1974

LESSON 20: THE SELECTIVITY OF FISHING GEAR

INTRODUCTION

One of the problems in harvesting the oceans is that the gear we use catches only certain groups of species. This is partly by design and partly due to its inherent limitations. But unless we bear this in mind we may come to some false conclusions about the quantity and types of fishes in the sea.

Passive gear like longlines may catch only hungry fish and passive gear like gillnets may take only active, swimming fish. Both types are size-selective owing to the type of hook or mesh size used, and they may be area selective depending on whether they are surface set or bottom set. The number of hooks per line or the number of meshes deep may also be a limiting factor.

Trawl nets catch a wide range of fish types and sizes. However, even they have their limitations. Most bottom trawls fail to catch high-swimming or fast-swimming species, or species that bury themselves in the mud. Mesh sizes have two separate effects. They retain all the fish above a certain size, but if small, they also restrict the flow of water and permit larger, fast-swimming fish to avoid the net mouth. In purse seines, both the mesh size and the speed of setting and pursing are important in determining the types of fish caught.

The important lesson is that when we study commercial catches and catch statistics, we must determine clearly what they do not tell us, as well as what they do tell us, about fish stocks. This is even more important when we come to evaluate the results of exploratory fishing programmes.

TOPICS COVERED

Details of limiting factors in the catching efficiency of different types of gear: gillnets, traps, hooks, trawls and seines. The different effects of mesh sizes, headline heights, towing speeds, time and depth of fishing. Fish behaviour in relation to fishing gear.

MATERIAL USED

There are some useful films available to illustrate this lecture. The Canadian Fisheries Department has a film of cod fish behaviour near a Newfoundland fish trap. The U.S.A. National Marine Fisheries Service has films of lobster behaviour around different types of lobsters pots and of herring escaping from a midwater trawl. The old British film "Fish and the Seine Net", FAO 289, has some good shots of undersized fish escaping from the cod-end.

EXERCISES

In a general class-teacher discussion, the students should be asked to give their interpretations of catch data (real or imagined) relative to different types of fishing gear. They should be shown not to jump to the conclusion that there are no more fish around, simply because one particular net failed to catch any more at one particular time.

REFERENCE BOOKS

Pope, J.A., et al., 1975 Manual of methods for fish stock assessment. Part 3. Selectivity of fishing gear. FAO Fish.Tech.Pap., (41) Rev. 1: 65 p.

LESSON 21: FISHERIES LEGISLATION

INTRODUCTION

There are few groups of people in the world who have suffered more from misguided and frustrating legislation than commercial fishermen. Fisheries legislation has an unfortunate history because so much of it was founded on misconceptions due to ignorance or lack of reliable data. Many laws that were supposedto help fisheries, actually had a negative result. On the international scene, fishing rights were often a pawn on the bargaining table and the resultant appropriations were unfair or inconsistent with fisheries management.

Legislation ought to be passed only when it is really necessary, and then only after extremely careful study of all available data, and consideration of all the possible consequences. Great care is needed to avoid jumping to conclusions on the state of a fishery or the reasons for an apparent decline.

Social factors are often important. Legislation may be needed to protect a group of inshore fishermen whose grounds may be invaded by larger more powerful vessels from other areas.

The side effects of legislation need to be examined. This applies also to rules by fishery departments regarding the sizes and types of vessels qualifying for credit schemes or subsidies of some sort.

Fishery laws that are sound and beneficial in the long term should have widespread support from those in the industry.

TOPICS COVERED

Brief historical review of fisheries legislation, with specific examples of good and bad laws:

Legislation to protect fish stocks	(see Lesson 19)
Legislation affecting fishing gear	(see Lesson 20)
Legislation to protect small scale fishermen	(see Lesson 23)
Legislation to protect limited markets from collapse	
Legislation to promote development	
Legislation to improve quality	

MATERIAL USED

It may be useful to show on chalkboard or flip chart how laws are drafted and put into effect, both on the national and international scene. Students should be clearly shown how they may, as industry members, approach the government on this subject. Legislators need to have the advice and help of fishermen as well as biologists.

EXERCISES

A class discussion on any interesting or controversial piece of fisheries legislation may be useful. The class could also go through a "mock" procedure of approach to government on the subject.

REFERENCE BOOKS

Koers, A.W., International regulation of marine fisheries. London, Fishing News (Books) Ltd., 1973 368 p.

LESSON 22: DIAGNOSING THE CONDITION OF A FISHERY

INTRODUCTION

If we trace the history of any particular fishery from the beginning of commercial fishing there, we ought to notice certain marked changes in the stock, its reproduction, and its yield as fishing effort increases. Initially there is usually a "fishing up" effect before the population stabilizes at a size and composition determined by biological and ecological factors and the current amount of fishing pressure. When over-fishing takes place, there are some clear "danger signals" that become apparent. These may include:

a reduction in the average size of fish caught;
a shortening of the season during which they are caught;
an absence of young fish or spawning fish; or
a decline in the total catch of any species which cannot be attributed to natural fluctuations or to a corresponding decrease in fishing effort.

It is well known that if one talks to fishermen in almost any part of the world, one will be told that fishing has declined in their fishery and there are now much less fish than there were before. But what a fisherman, or a fish merchant, or a consumer, or a biologist, means by a shortage of fish, may be quite different. Even in the best developed fisheries, there is a lack of sufficient data on which to base studies. In less well developed fisheries we must rely more on an amalgamation of information from many odd sources when we commence our studies. Each piece of information must be weighed carefully against another before we can piece together at least part of the intricate jigsaw giving the fishery's condition from the biological, economical and social viewpoints.

For example:

(a) If we increase the number of fishing units, the result will probably be a lower catch per unit effort or a shortage of fish per fishermen.

(b) If we increase the number of consumers, the result may be less fish per consumer or a shortage of fish in an enlarged market.

(Both the above conditions may exist temporarily without the fishery having attained the optimum biological or economical yield.)

Differing year classes, seasonal fluctuations and natural factors, may result in temporary reductions to populations which ought not to be interpreted as real or permanent reductions.

Catch statistics are notoriously prone to false interpretation. They may reflect changes in the market for certain species, changes in the economy of operation, or even the personal preferences of the fishermen for a particular vessel, gear, region or way of life.

TOPICS COVERED

Brief theoretical history of a fishery from its virgin state to a stable maximum continuous yield, through fluctuations in nature and in fishing effort. Projection of this history to a hypothetical overfishing situation. Explanation of the interplay of factors and the nature of the "evidence" at each stage in the fishery.

MATERIAL USED

Several well-prepared flip charts illustrating the progress of a fishery would be ideal for use.

EXERCISES

The instructor should pause at appropriate points in the lecture to allow class participation by discussion or by question-answer.

REFERENCE BOOKS (See Lesson 15)

LESSON 23: CURRENT CONFLICTS

INTRODUCTION

Fisheries management involves more than just the prevention of over-fishing. It is also concerned with resolving or reducing the numerous conflicts and disagreements between different groups within the fishing industry. These conflicts arise when different fleets compete for the same fish or on the same limited fishing grounds, or for the same markets. Some examples:

INDUSTRIAL FISHING VESSELS versus SMALLER PRIVATELY-OWNED UNITS. Company-owned deep sea fleets are finding it more difficult to operate as national fishery limits are extended ever further. They may be forced to compete with inshore fleets for limited stocks of fish in home waters.

CONFLICTING METHODS. Trawlers may destroy the fishing gear set by gillnetters, liners or trap boats. Incompatible methods should be kept apart as far as possible.

INTERNATIONAL CONFLICTS. These become more complex where neighbouring countries share the same stocks of fish.

While industry does not make fisheries policy itself, what it has to say will greatly influence the government in its policy decisions. Legislation takes time as it needs to be carefully planned with wisdom and foresight. To safeguard their livelihood, fishermen and fishing companies should operate within the spirit as well as the letter of fisheries legislation. To protect themselves and to forestall the introduction of ever more laws and regulations, they should exercise discretion and be prepared to limit or diversify their operations as the circumstances may warrant.

TOPICS COVERED

Summary of current national and international fishery conflicts with an explanation of the background of the major disputes. Efforts to solve these problems. Potential sources of future conflict.

MATERIAL USED

The views of national, coastal or artisanal fishermen may be presented by a member of that group. Alternatively, the views of opposing groups within the industry may be presented by two students at a "mock" inquiry, with the class acting as a jury. The instructor should prepare the statements to be read on behalf of both parties beforehand.

EXERCISES

In view of the impending examination, students should review all the work covered in the past ten lessons.

REFERENCE BOOKS

Rothschild, B.J. (ed.), World fisheries policy. Seattle, U.S.A., University of Washington Press, 272 p. 1972

LESSON 24: EXAMINATION

Students should be examined on the content of Lessons 14 to 23 to determine how much they have absorbed or understood. The examination should consist of at least ten questions on the subjects listed below. In addition they should be asked to submit at least four different graphs they have constructed themselves from hypothetical or real data, with a brief explanation of each. The graphs should have been completed in the student's own time during the preceding two weeks.

EXAMINATION

Ten questions dealing with:

World Fish Catch; recent increases in; figures for main groups
National fish catch; prominent species, weight and value, recent trends
Endangered or over-exploited species
Under-exploited resources
Russell's equation, basic theory and meaning of terms
Theoretical shape of fish population and behaviour under exploitation
Significance of yield curves based on biological and economical data
Methods used to control fishing effort and to protect young fish
Selectivity or limitations in catching capacity of chief types of fishing gear
Kinds of fishery legislation and their purposes
Analysis of symptoms in a changing fishery

SUBMISSION

From home assignment; at least four graphs illustrating yield curves from data on fishing effort, total yield, number of units, value of catch, cost of fishing effort, recruits to fish population, size of fish at first capture, etc.

Each graph should be accompanied by an explanation of the data and an interpretation of the curve.

LESSON 25: COURSE SUMMARY AND REVIEW

Following the final examination, the instructor may well be aware of some points that require revision and these should be attended to on the last day of the class. The students should have their term papers and home assignments returned to them for future reference.

The instructor should then review the course as a whole and relate it to current national plans for fishery development. The fishery resource is a national asset which, if harvested with wisdom, will remain productive for future generations.

The students ought not to leave the course with the idea that the interests of the fishing industry and conservationists are necessarily in opposition. In the long term, they

work for each other's good. With goodwill and understanding on both sides they can achieve workable solutions to many of the problems that arise. Governments are forced to intervene at times, occasionally for reasons not directly related to the immediate problem, but this happens in every country.

TOPICS COVERED

Examination results, return of term papers and home assignments, review of work. Course review, parts one and two (fisheries biology and management).

EXERCISE

A group discussion would be useful to end this final class session. The discussion should centre on questions like "What is my personal policy or philosophy to be, relative to fish stocks, in my work as one of the harvesters of the ocean?" Students should also be encouraged to raise last minute questions on any point which is not clear to them.